Next-Generation Bioacoustic Analysis Software

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LONG-TERM GOALS

In the past two decades, awareness has grown that acoustic methods are often the best means for studying and monitoring marine mammals. Acoustic methods, for instance, have long been used for detection and study of sperm whales, in part because of the difficulty of visual detection: Visual surveys have been estimated to miss 38% of sperm whales that are on a ship's trackline (Barlow and Rankin 2004), and more at greater distances from the trackline. Other species are similar or worse; for instance, it is estimated that approximately 85% of Cuvier's beaked whales on the trackline are missed with visual scanning (J. Barlow, pers. comm). Acoustic methods, in contrast to visual ones, function well in darkness, fog, high sea states, and other inclement viewing conditions. Via the use of autonomous recorders, acoustic methods can also be used in remote or inhospitable areas (Širović et al. 2004, Mellinger et al. 2008) where visual monitoring would be impracticable or impossible. Software tools are needed for analyzing such data sets, even for such simple tasks as manually scanning spectrograms to find calls of interest. Acoustic localization of calling animals is often performed; whether estimates are in one dimension (bearing), two (X-Y position), or three (X-Y-Z position), analysis software is necessary. Marine mammal acoustic data is often collected in very large data sets, necessitating automated methods for data analysis. For instance, AURAL autonomous recorders (Multi-Électronique, Inc.) operate at a sample rate of 32 kHz, so that a one-year data set is 2 terabytes (TB) in size. Another type of autonomous recorder, the HARP (Wiggins 2003; J. Hildebrand, pers. comm.), operates at even higher sample rates – up to 200 kHz – making a one-year data set 12.6 TB in size. Automation tools are clearly needed for data sets of this scale.

Starting in 2000, ONR funded the development of one such tool, Ishmael (Mellinger 2001). It is a user-friendly bioacoustic analysis package for Windows. It includes displays of sound waveforms and spectrograms, recording capability for real-time input, several methods for acoustic localization, beamforming, several methods for automatic call recognition, and a sound annotation facility. Ishmael is aimed at users wishing to analyze large volumes of data quickly and easily. Ishmael quickly became popular, with thousands of downloads by users; a large proportion those downloads were in active use, and a survey in 2005 showed that 46% of respondents use it regularly. It has also been used in much ONR-funded research:

In this project, we have implemented a number of improvements and updates to Ishmael.

OBJECTIVES

- Hire and train a software engineer to make improvements to Ishmael.
- Implement new audio I/O.
- Implement improved localization.
- Implement improved detection and classification.
- Implement improved acoustical measurements.
- Implement programming interfaces.
- Update Ishmael's documentation for these improvements.
- Create user group / web site for users to share information and tips.

APPROACH

The approach was to hire a software engineer to perform most of that above tasks in collaboration with myself. Research assistants will also perform much of the updating of documentation.

WORK COMPLETED

The software engineer, Jonathan (Jon) Dodge, was hired and started work on Ishmael in early December 2010. Unfortunately, Mr. Dodge, after learning many of the internal details of Ishmael and completing significant work on it, stopped showing up for work in late January 2013, despite repeated unreturned phone messages and emails. (Mr. Dodge had done a similar thing more briefly in August 2012, returning quite apologetic; after he returned, I told him he would terminated if it happened again and he said it would not happen again.) Consequently, his position was terminated in February.

After that, I (Dave Mellinger) started doing the software engineering for this project. As I had time to work on it only a small part of the time, work went more slowly than planned, and this necessitated no-cost extensions for this project.

In late spring 2014, another project involving Ishmael, "Simple performance-characterized automatic detection of marine mammal sounds", was funded by the Navy's Living Marine Resources program. This project includes enough funding for software development that it became possible to combine those funds with funds from this project and hire a software engineer to complete both projects.

That software engineer, Curtis Lending, was hired in October 2015 and has now been working for nearly one year. Mr. Lending initially spent several months learning Ishmael's structure and internal functioning, then began implementing improvements to it.

RESULTS

The following changes have now been implemented:

- Interfaced to MATLAB so that detection and classification algorithms may be written in MATLAB code and used from within Ishmael. This was done in collaboration with Chris Marsh of San Diego State University.
- Implemented an interface for detection and classification algorithms written in Java.
- Implemented saving of specific sets of parameters, so that user can, for instance, save and then load only those parameters that affect detection processes without affecting localization, file-saving, user action options, screen displays, etc.
- Updated Ishmael's documentation. This includes revisions to the textual manual as well as new short videos explaining how to do certain tasks.
- Kept Ishmael operating successfully on Windows 8 and Windows 10.
- Made Ishmael once again operate on MacOS. It had once worked on the Mac, stopped a couple of years ago, and now works again. Ishmael on Mac uses the WineBottler "wrapper" to interface Windows system calls.
- Fixed a prominent bug in that Ishmael would crash upon exiting.
- Fixed a number of minor bugs.

In addition, an interface to the Marine Mammal Monitoring on Navy Ranges (M3R) acoustic system was implemented so that Ishmael can receive M3R acoustic streams and use its detection, classification, and localization methods. This was done using other funding (see Related Projects) so it is mentioned here only for reference.

IMPACT/APPLICATIONS

Ishmael is used for marine mammal acoustic monitoring in many places around the world. Having the new features should make it more useful to researchers everywhere.

TRANSITIONS

The Navy's Living Marine Resources program is funding a project to transition Ishmael to fleet use. This will involve several steps, both in software development as well as in outreach: Ishmael will be enhanced to download detection configuration files across from an archive of such configuration files, and to display performance data for these configurations. Part of the project also involves teaching a number of tutorials/classes, done in collaboration with BioWaves, Inc., on using Ishmael for real-time monitoring of marine mammals.

RELATED PROJECTS

Advanced Methods for Passive Acoustic Detection, Classification, and Localization of Marine Mammals (award numbers N0001411IP20086 and N0001411WX21401). This ONR-funded effort is

developing improved algorithms that will be offered to users in a user-friendly way by implementing them in Ishmael in the future.

Simple Performance-Characterized Automatic Detection of Marine Mammal Sounds (award number N39430-14-C-1434), funded by the Navy's Living Marine Resources program. Described above in the Transitions section.

REFERENCES

Fristrup, K.M. (1992). *Characterizing Acoustic Features of Marine Animal Sounds*. Technical Report WHOI-92-04, Woods Hole Oceanographic Inst., Woods Hole, Massachusetts.

Kandia, V., and Y. Stylianou. 2006. Detection of sperm whale clicks based on the Teager-Kaiser energy operator. Appl. Acoust. 67:1144-1163.

Mellinger, D.K., R.P. Morrissey, S.W. Martin, L. Thomas, T.A. Marques, and J. Yosco. 2011. A method for detecting whistles, moans, and other frequency contours. J. Acoust. Soc. Am. 129:4055-4061.